Wide Area Augmentation System (WAAS) Industry Engagement

Dan Hanlon
WAAS Program Manager
Federal Aviation Administration

David Beering
WAAS Study Lead
Infinite Global Infrastructures, LLC

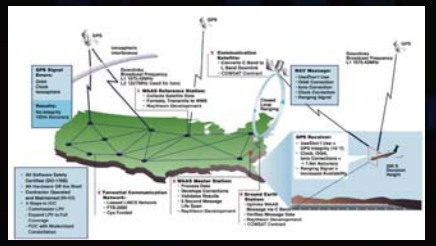
The National Airspace (NAS) Is a System Of Systems

- **The NAS contains approximately 13,000 pieces of infrastructure**
  - 18,300 airports
  - 21 air route traffic control centers
  - 197 terminal radar approach control (Tracon) facilities
  - 460 air traffic control towers
  - 75 flight service stations
  - Approximately 4,500 air navigation facilities
  - 48,000 FAA personnel / 600,000 pilots managing over 280,000 aircraft
- **Annual Maintenance Costs Run Approximately $350M**

Evolution of IFR Navigation in the National Airspace

Four-course range

VOR, DME, Tacan

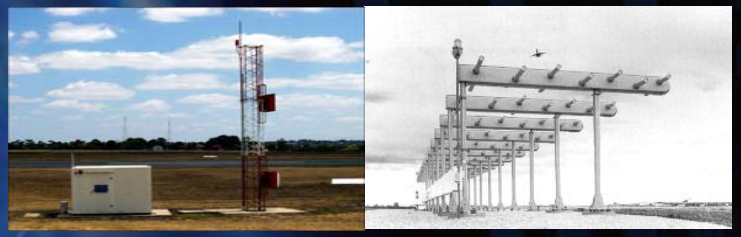


WAAS

NDB

Loran C

GPS



Instrument Landing System

Microwave Landing System

LAAS

1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

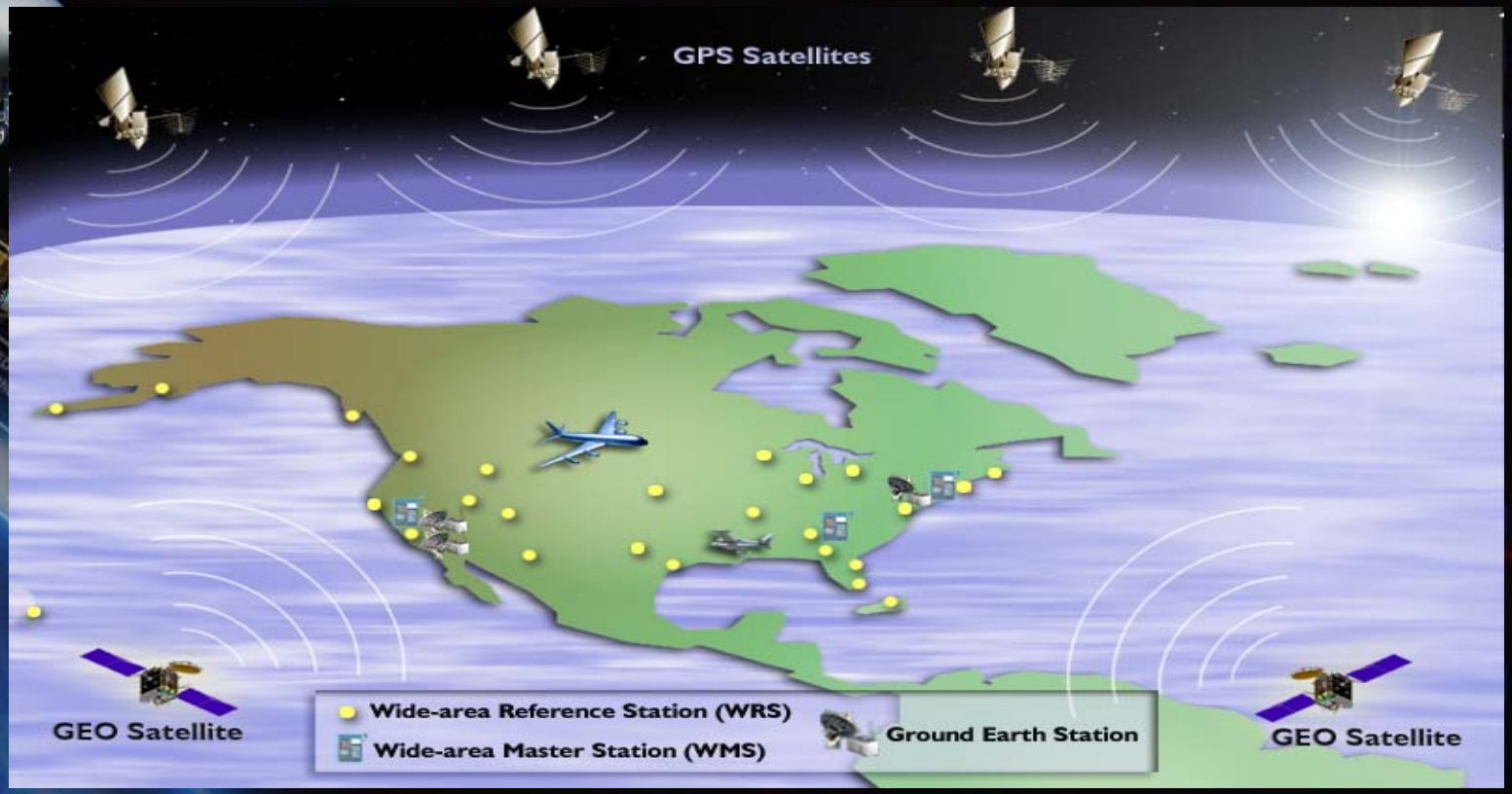
Why Augment GPS?

- **GPS provides significant benefits to aviation**
  - GPS has been authorized for use in aviation since 1992
  - Over 3500 non-precision GPS instrument procedures have been developed
- **Current GPS constellation cannot support requirements for all phases of flight**
  - Integrity is not guaranteed
    - All satellites are not monitored at all times
    - Time-to-alarm is from minutes to hours
    - No indication of quality of service
  - Accuracy is not sufficient
    - Even with SA off, vertical accuracy > 10 m
  - Availability and continuity must be met

Satellite-Based Augmentation Systems (SBAS) are a global phenomenon

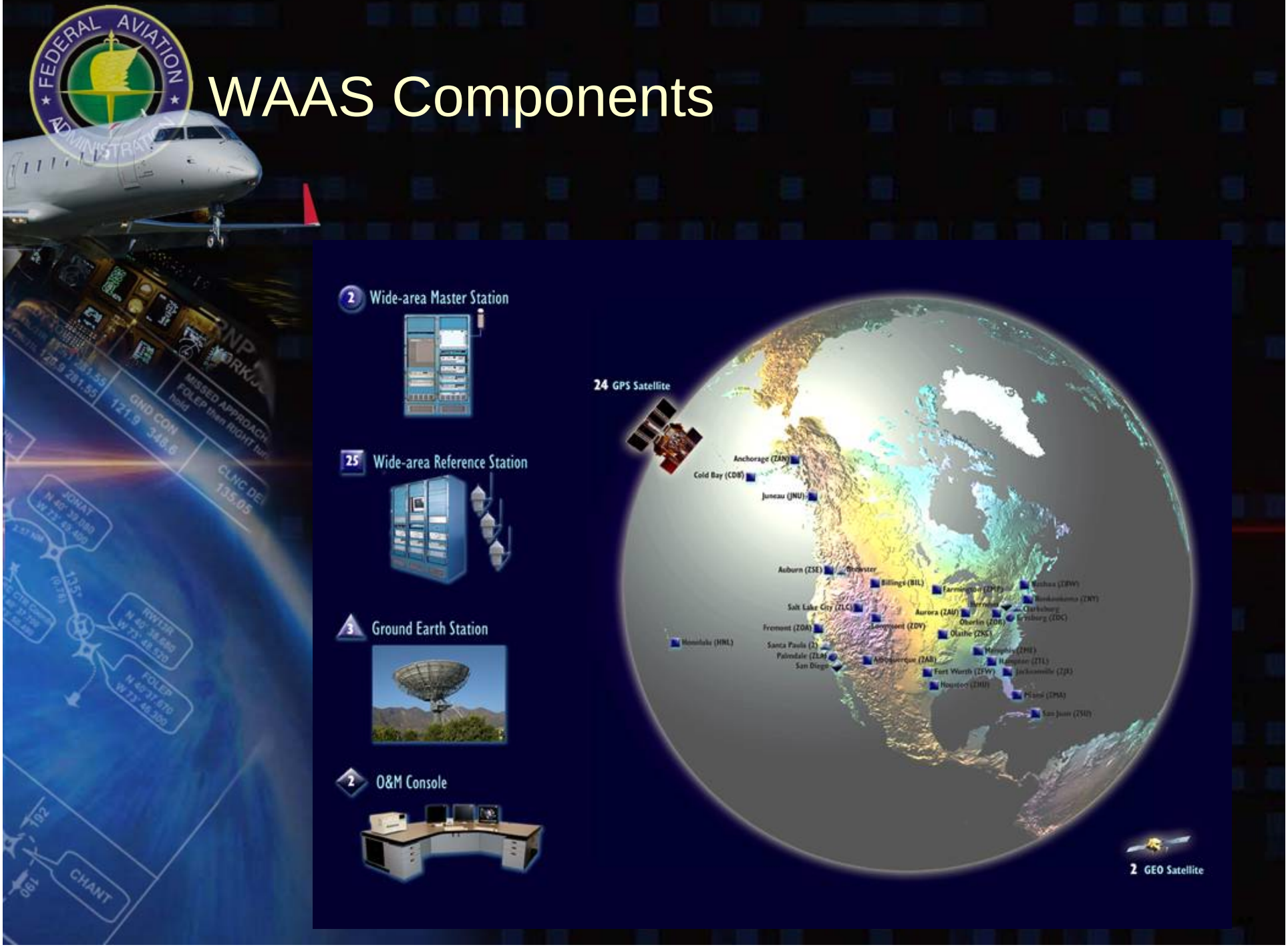
- **United States**
  - WAAS (Wide Area Augmentation System)
- **Europe**
  - EGNOS
- **Others**
  - MSAS (Japan)
  - GAGAN (India)

What is WAAS?



- **WAAS consists of:**
  - **25 reference stations**
  - **2 master stations**
  - **2 geosynchronous satellites**
  - **3 uplink stations**
- **WAAS augments the GPS constellation to meet the necessary integrity, availability, accuracy, and continuity for use in all phases of flight**

WAAS Components



WAAS Status

- **The science project is over!**
  - WAAS has been available for recreational use and visual flight rules since August 2001
  - WAAS was approved for aviation instrument operations on July 10, 2003
  - Provides 100% coverage of Continental US & Alaska from 100,000ft. to surface
  - Began publication of WAAS specific approaches in September 2003
  - Continuing to develop the system to expand vertical navigation to most of North America

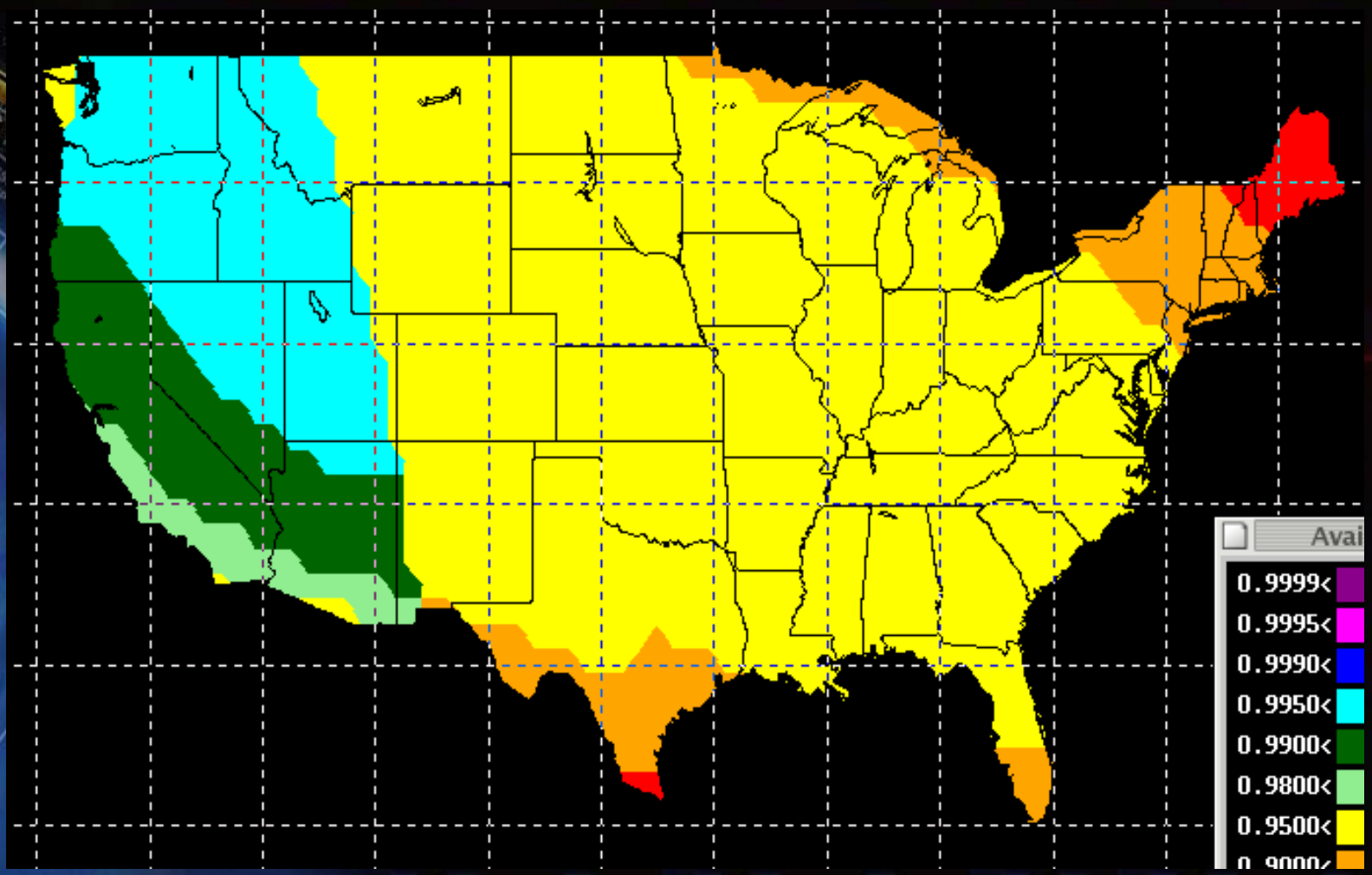
WAAS Schedule

- **IOC (Initial Operating Capability)** — **2003**
- **Incremental improvements** — **2003 - 2008**
  - Ground system development ends
  - System improvements will be brought online incrementally
  - End state performance will result in greater availability of approach with vertical guidance (LPV - 250 foot minimums)
    - 99% CONUS
    - 95% in most of Alaska
- **Two GEOs in view to all users over all CONUS and Alaska** — **2007**
- **GPS modernization** — **2013**
  - L5 frequency (block IIF & GPS III)
  - WAAS 200’ minimums (first WAAS precision approach)
  - Better interference mitigation

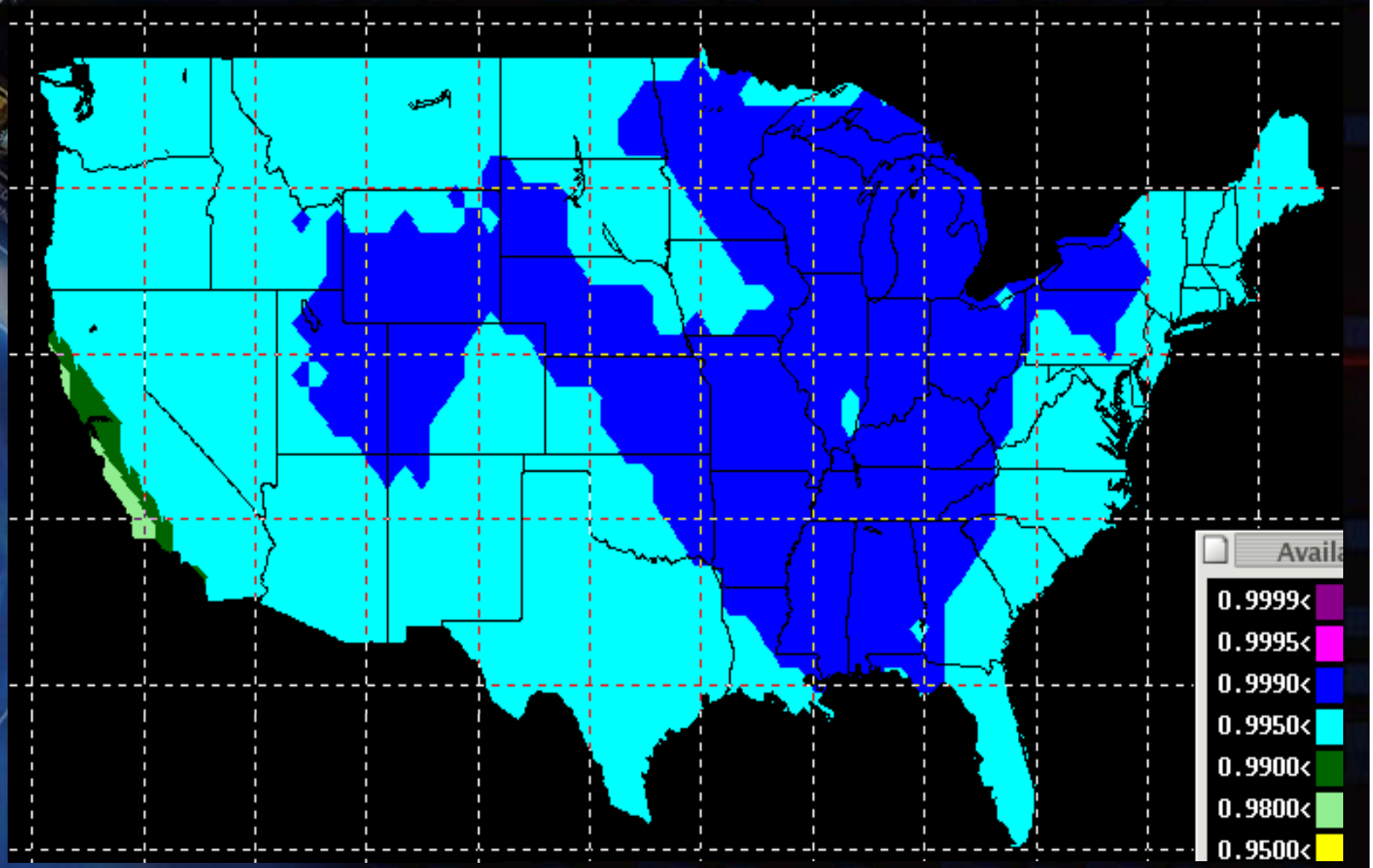
WAAS Capabilities

- **Efficacy of WAAS**
  - Enhances en-route navigation performance over GPS alone
  - Enhances non-precision approach capability over GPS alone
  - Allows WAAS equipped users to fly published LNAV/VNAV procedures to minimums as low as 350 feet (Same as RNP .3)
  - Allows WAAS equipped users to fly new LPV procedures which provide precision approach capability to runways where there is no ILS. These can be flown to minimums to as low as 250 feet
- **100% Coverage CONUS & Alaska From 100,000 Ft. To Surface (LNAV)**
- **Horizontal Accuracy <1.5M**
- **Vertical Accuracy <3M**
- **Better Than 99.99% Availability Of System**
- **95% Availability In CONUS Of Approach with Vertical Guidance**
  - 250’ Minimum

Current LPV Approach Availability



Predicted LPV Availability
2008 Full LPV Capability



Development Activities

- **System Enhancements:**
  - 13 Additional WRSs To Improve Availability And Coverage
    - 4 Alaska
    - 5 Mexico
    - 4 Canada
  - Replace Current GEO Satellite Constellation
    - Will Have Two Satellites In View To All Users At All Times At All Locations
    - Higher Power Levels Provide More Stable Signal

North American WAAS

WAAS Avionics

- **Certified receivers**
  - Over 2,000 Garmin GNS-480s sold
    - Currently selling approximately 300 per month
  - Chelton systems with Free Flight Systems WAAS sensor
- **Recent developments**
  - 40,000 Garmin units in field that can be upgraded
    - Upgrade cost expected to be $1500
  - The FAA is currently teaming with other manufacturers to develop additional LPV receivers in all functional classes

WAAS Avionics (cont.)

- Rockwell-Collins In Development Of WAAS Capability In Multi-Mode Receiver (MMR)
- Free Flight Systems Upgrading Sensor In Shelton CAPSTONE Avionics To Provide Vertical Approach Capability
- Other Manufacturers Developing WAAS/SBAS Capable Avionics
- WAAS Avionics Can Be Installed In All Aircraft (Avionics Not Yet Available For All)
- WAAS Integration Into Full Flight Management System (FMS) Capability Expected Within 18 Months

Number of Runway Ends at Paved Runways 3200’ or Longer – 49 Candidate States*

Alabama: 210	Iowa: 196	Nevada: 134	South Dakota: 120
Alaska: 152	Kansas: 238	New Hampshire: 34	Tennessee: 180
Arkansas: 202	Kentucky: 132	New Jersey: 78	Texas: 1122
Arizona: 248	Louisiana: 146	New Mexico: 190	Utah: 132
California: 596	Maine: 76	New York: 214	Vermont: 22
Colorado: 208	Maryland: 66	North Carolina: 234	Virginia/DC: 172
Connecticut: 30	Massachusetts: 86	North Dakota: 140	Washington: 184
Delaware: 20	Michigan: 312	Ohio: 274	West Virginia: 64
Florida: 498	Minnesota: 224	Oklahoma: 232	Wisconsin: 280
Georgia: 290	Mississippi: 150	Oregon: 160	Wyoming: 100
Idaho: 102	Missouri: 210	Pennsylvania: 178	
Illinois: 270	Montana: 194	Rhode Island: 16	TOTAL: 9642
Indiana: 198	Nebraska: 176	South Carolina: 152	

*Eligible for 1 Mile or Greater Visibility

Focus Groups – Purpose

- **So far WAAS has evolved in a similar fashion to GPS**
  - Little industry involvement
  - Quiet uptake in certain markets
  - Limited operational implementation
- **The Focus Group project allows the FAA to reach out to five communities of pilots in order to determine the value of WAAS in those five flying environments according to practitioners**
  - Helicopter Operators
  - Corporate Flight Departments
  - Cargo Carries
  - Scheduled Commuter Carriers
  - Scheduled Mainline Carriers
- **Focus Group meetings are being held in a variety of large cities across the US over a period of six months**

Focus Groups – Release of Findings

- **After the Focus Group effort has concluded, the IGI/FAA team will release an official report outlining the findings of the study. These findings are expected to include:**
  - Recommended priorities for implementation of WAAS approaches
  - Specific procedures that should be developed
  - Recommended changes in airspace configuration to leverage SBAS capabilities and increase efficiency in the NAS
  - Additional avionics and aircraft equipage considerations
  - Others

Early Insights – General Aviation

- While the Focus Group activity has not specifically engaged the General Aviation community, there are important insights relating to that community that have emerged
- The Aircraft Owners & Pilots Association (AOPA) has written extensively about WAAS and is strong advocate of the system in the flying community and on Capitol Hill
- WAAS-equipped General Aviation aircraft can have a navigation capability roughly equivalent to a $2 million commercial airliner flight deck for less than $20,000. This makes it possible to GA aircraft to fly similar procedures and operate more effective and efficient operations concurrently with larger aircraft, especially in complex airspace

Early Insights – Fixed-Wing Aircraft

- **WAAS can bring significant benefits to fixed-wing operations**
  - Precision curved approaches
  - Long-final precision approaches
  - Precision guidance for tricky visual approaches
  - Better guidance for night operations into unfamiliar airports
  - Precision guidance for noise abatement procedures
  - Required ground-based navigational aids inoperative
  - Localizer (ILS) interference on ground
  - Ground operations efficiencies for ILS Hold Short lines

Early Insights – Vertical Flight

- **The helicopter community has been an early advocate of WAAS for low-altitude operations, but little was known about WAAS by this community prior to the Focus Group engagement**
  - Engagement with the vertical flight community has been coordinated with HAI and AMSAC, initially
  - Focus Group has worked with EMS, Public Safety, and News Helicopter Operators
  - Precision vertical guidance for low-altitude air operations is critical
  - Line-of-sight limitations and locations of VOR signals make these NAVAIDS less useful for helicopter operations
  - Precision instrument approaches need to be developed to commonly visited locations that are not airports, i.e.
    - Heliports
    - Hospital rooftops
- **IFR operation is not necessarily a requirement, as few helicopters are actually equipped for IFR operations, and even fewer flight crews are certified and current to operate IFR**
- **Local weather reporting is critical**

Early Insights – Corporate Flight

- **Night circling approaches to unfamiliar airports**
- **Non-precision approaches to short runways, especially at night**
- **There are a huge number of runways with no precision approach procedures available. These runways could be equipped with WAAS approaches with no ground equipment required**